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Welch

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(54) **PUMP**

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F04D 29/42 (2006.01)

(52) **U.S. Cl.** **415/199.1**; 415/214.1; 415/201; 415/206; 415/211.2; 415/230; 417/360; 417/423.3; 417/423.14

(58) **Field of Classification Search** 415/199.1, 415/201, 203, 206, 182.1, 211.2, 174.2, 230; 417/360, 423.15, 423.14, 423.3
See application file for complete search history.

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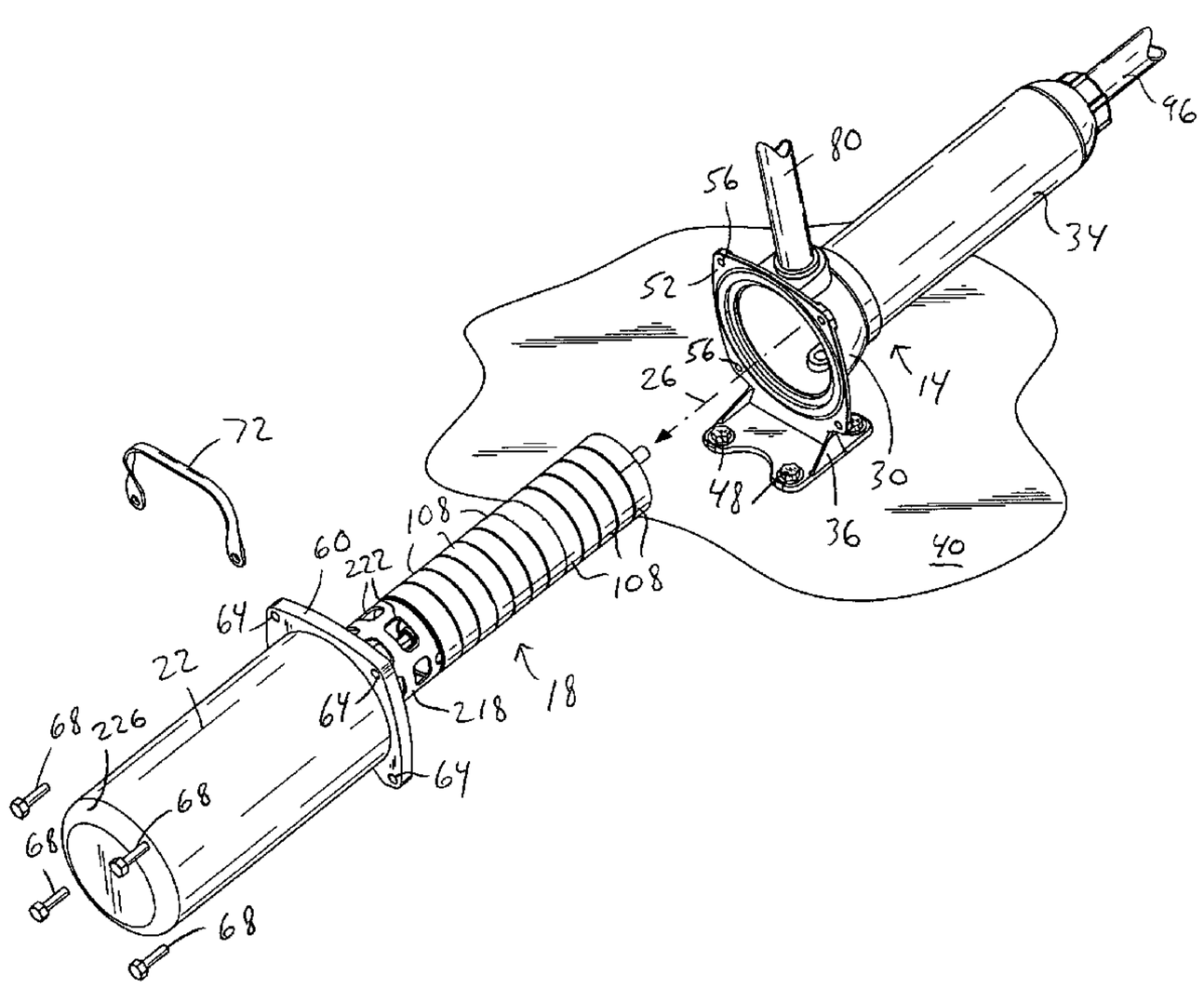
(57) **ABSTRACT**

Some embodiments of the present invention provide a pump including a pump housing having an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit. The pump also includes a pump shaft rotatably supported in the pump housing and a plurality of impellers coupled for rotation with the pump shaft. The pump further includes a motor removably coupled to the pump housing. The motor has an output shaft drivably coupled to the pump shaft. The pump also includes a spacer positioned between the plurality of impellers and the motor. The spacer includes at least one aperture to access and decouple the output shaft and the pump shaft. The motor, spacer, pump shaft, and the plurality of impellers are removable from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing.

55 Claims, 7 Drawing Sheets



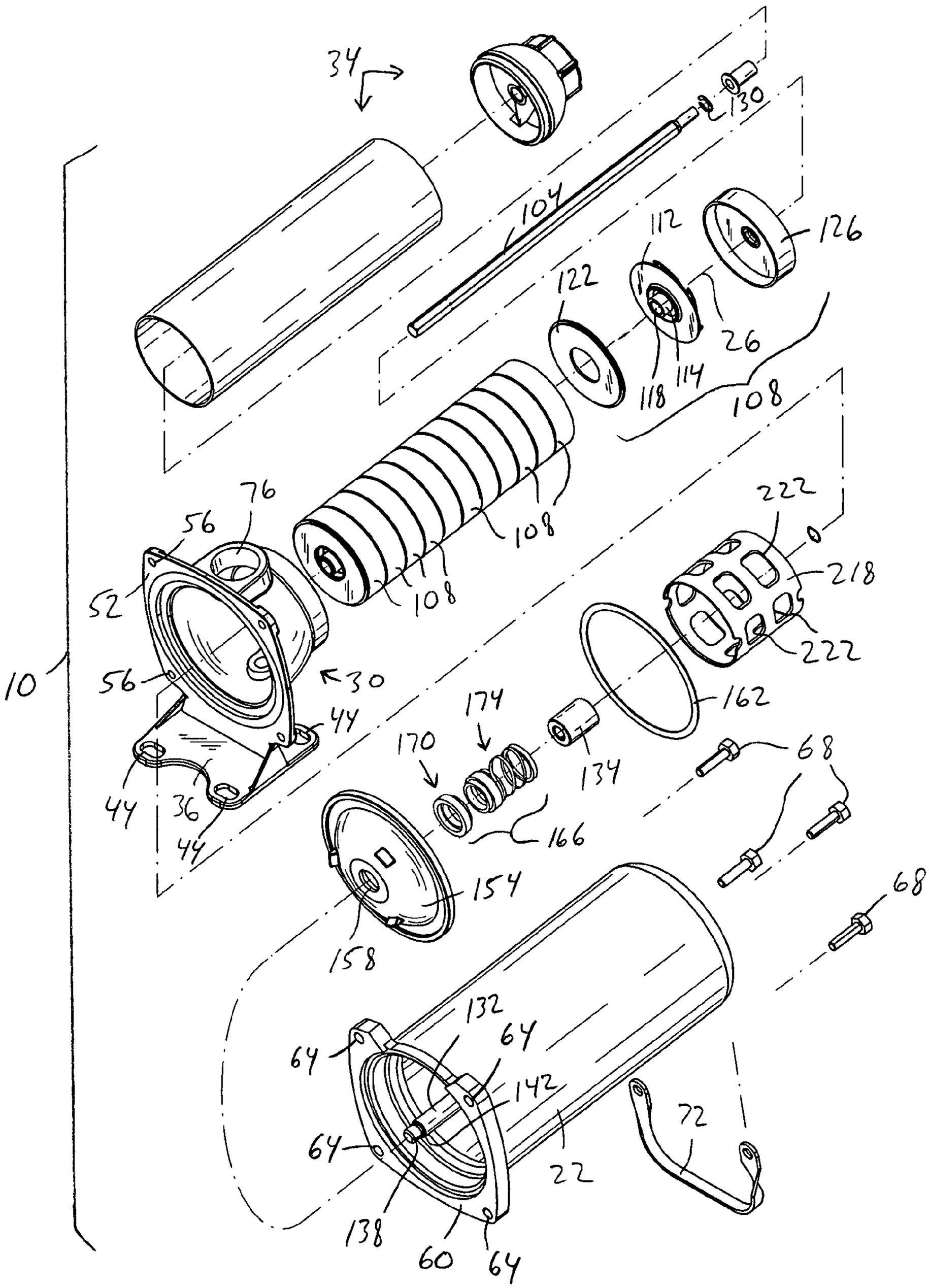

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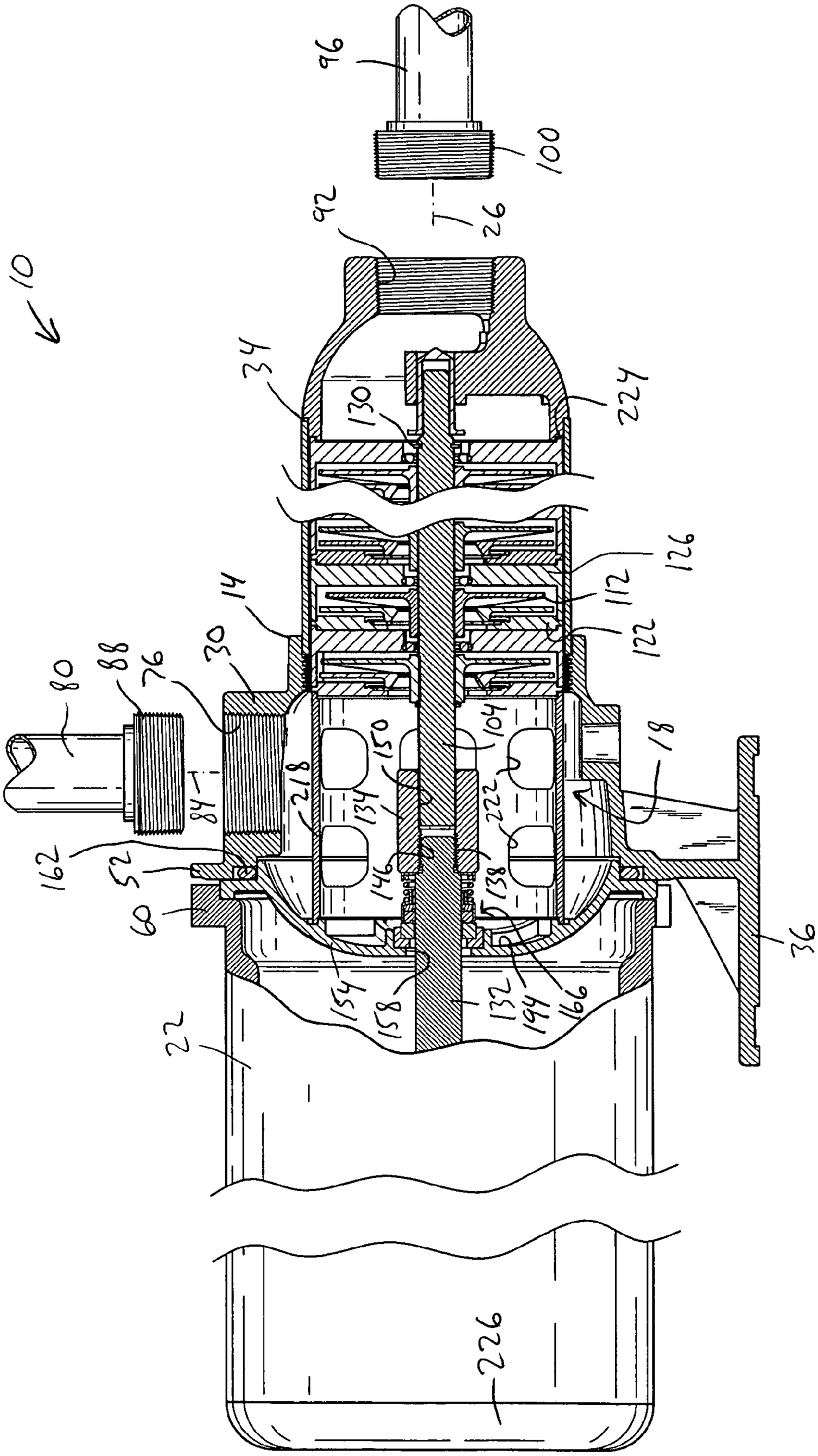
FIG. 1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226

FIG. 2

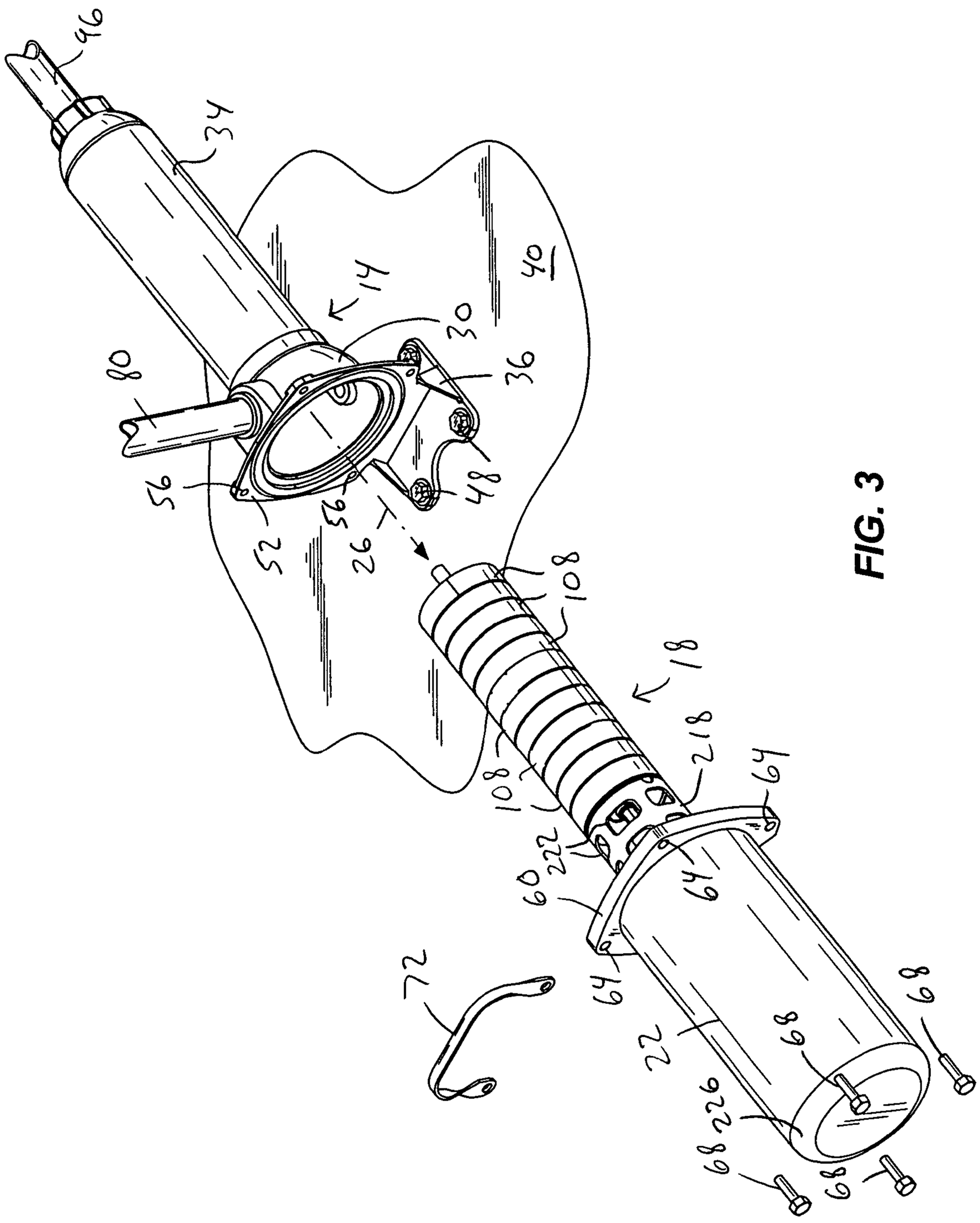
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FIG. 3

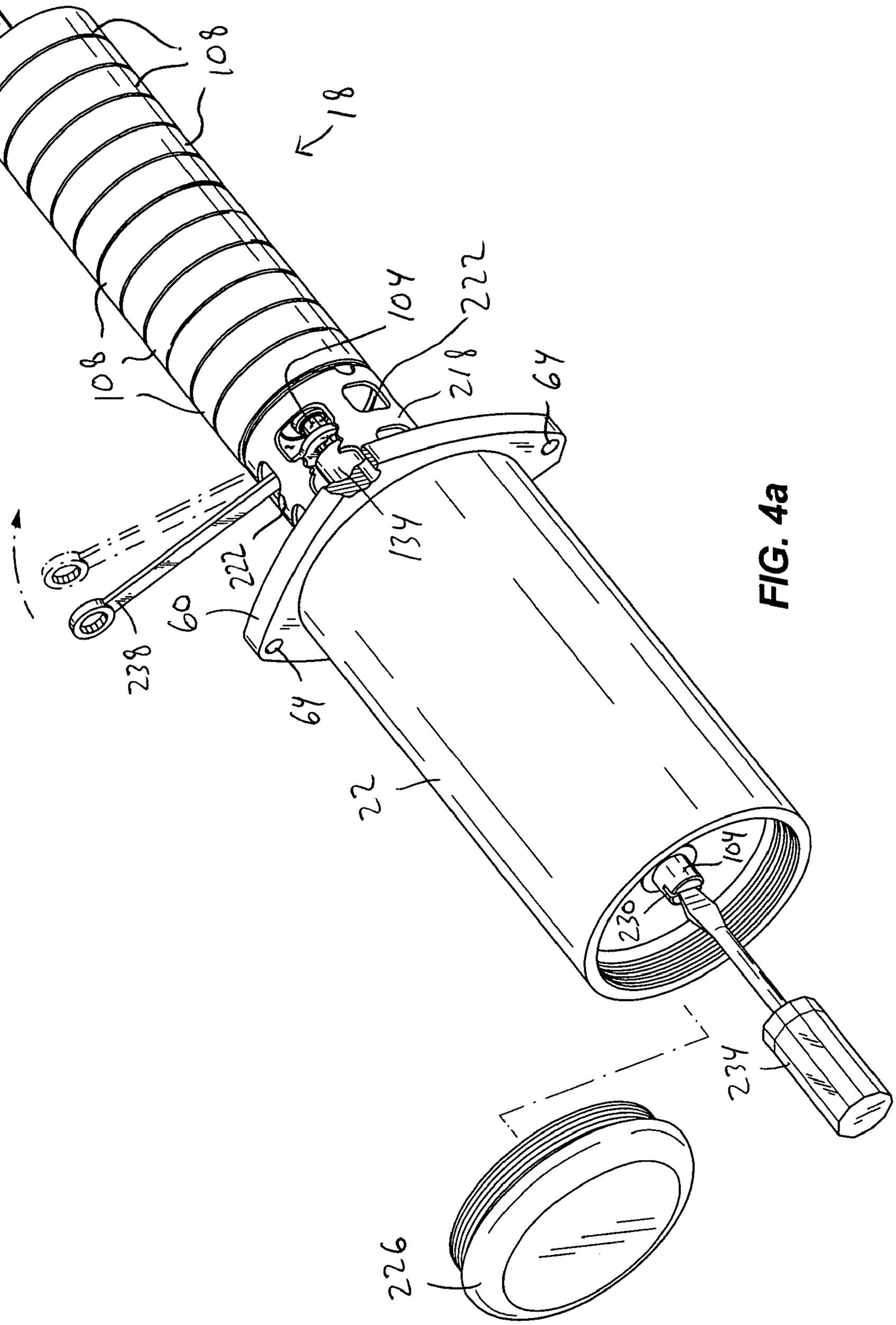

FIG. 4a

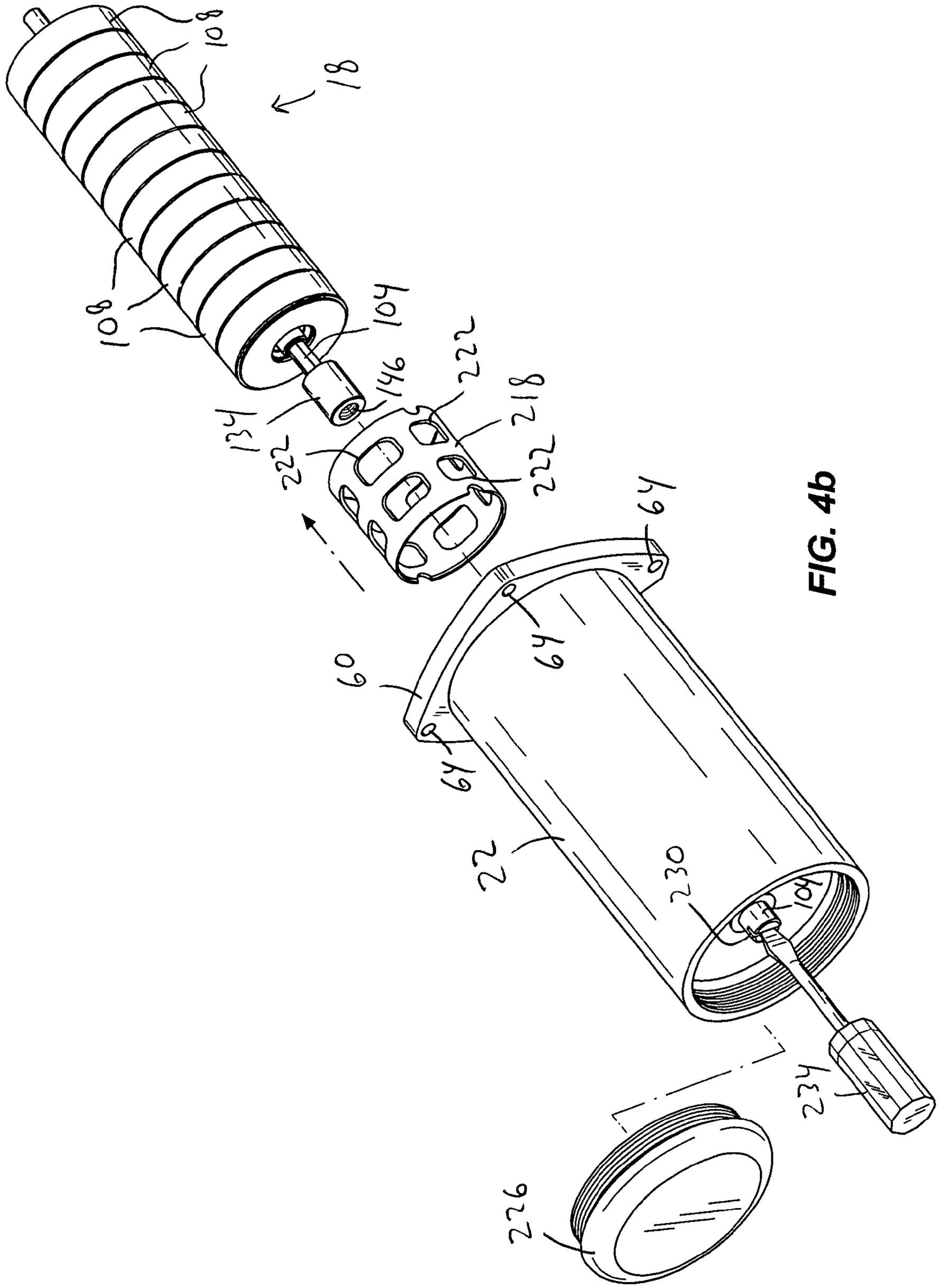
108
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FIG. 4b

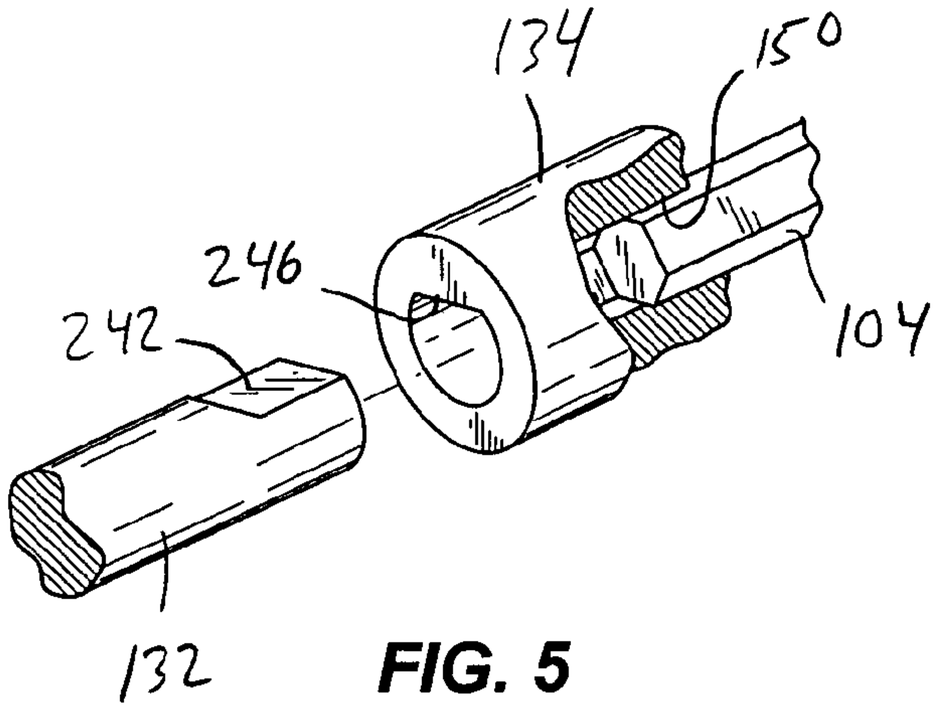
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FIG. 5

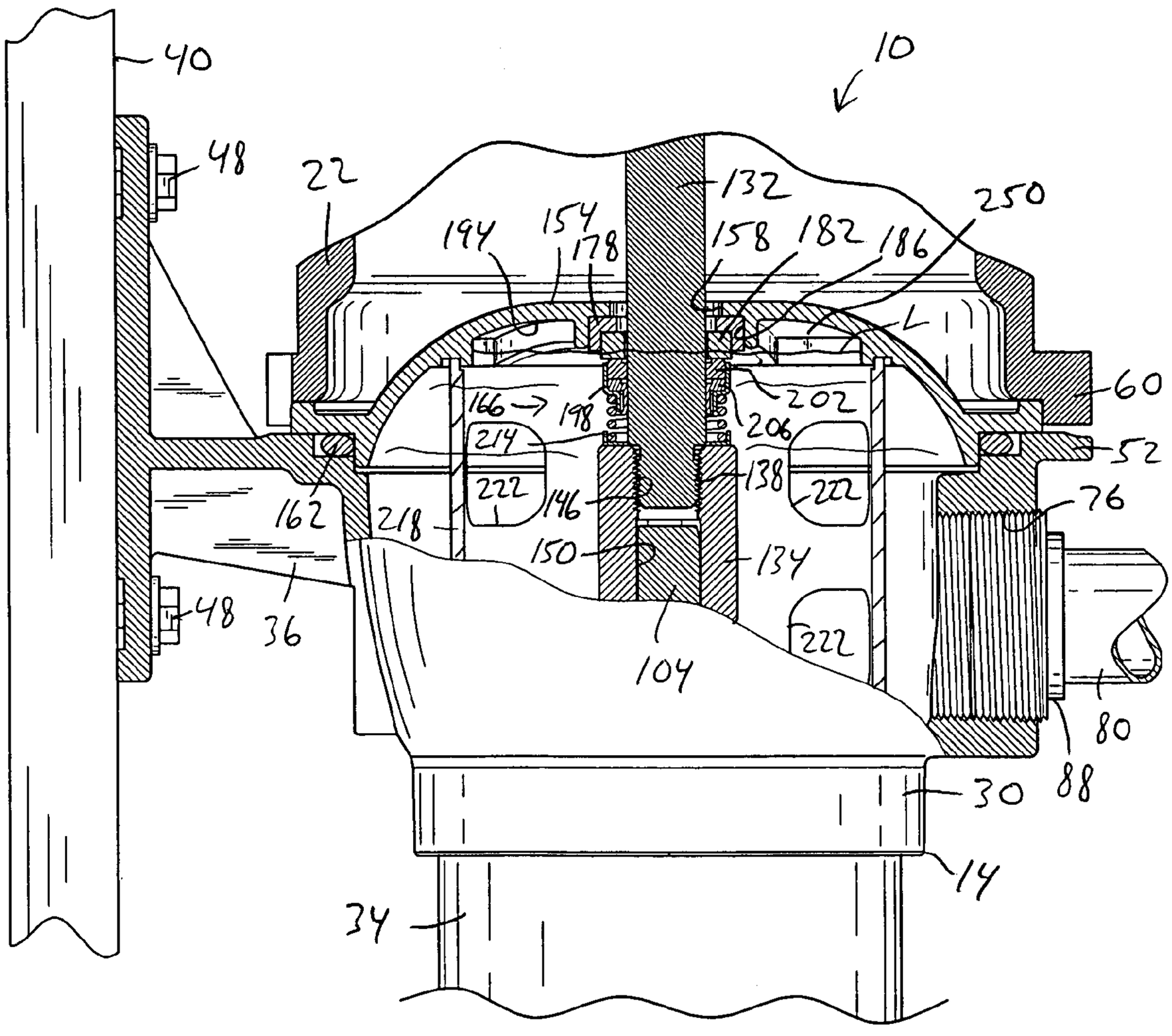
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FIG. 6a

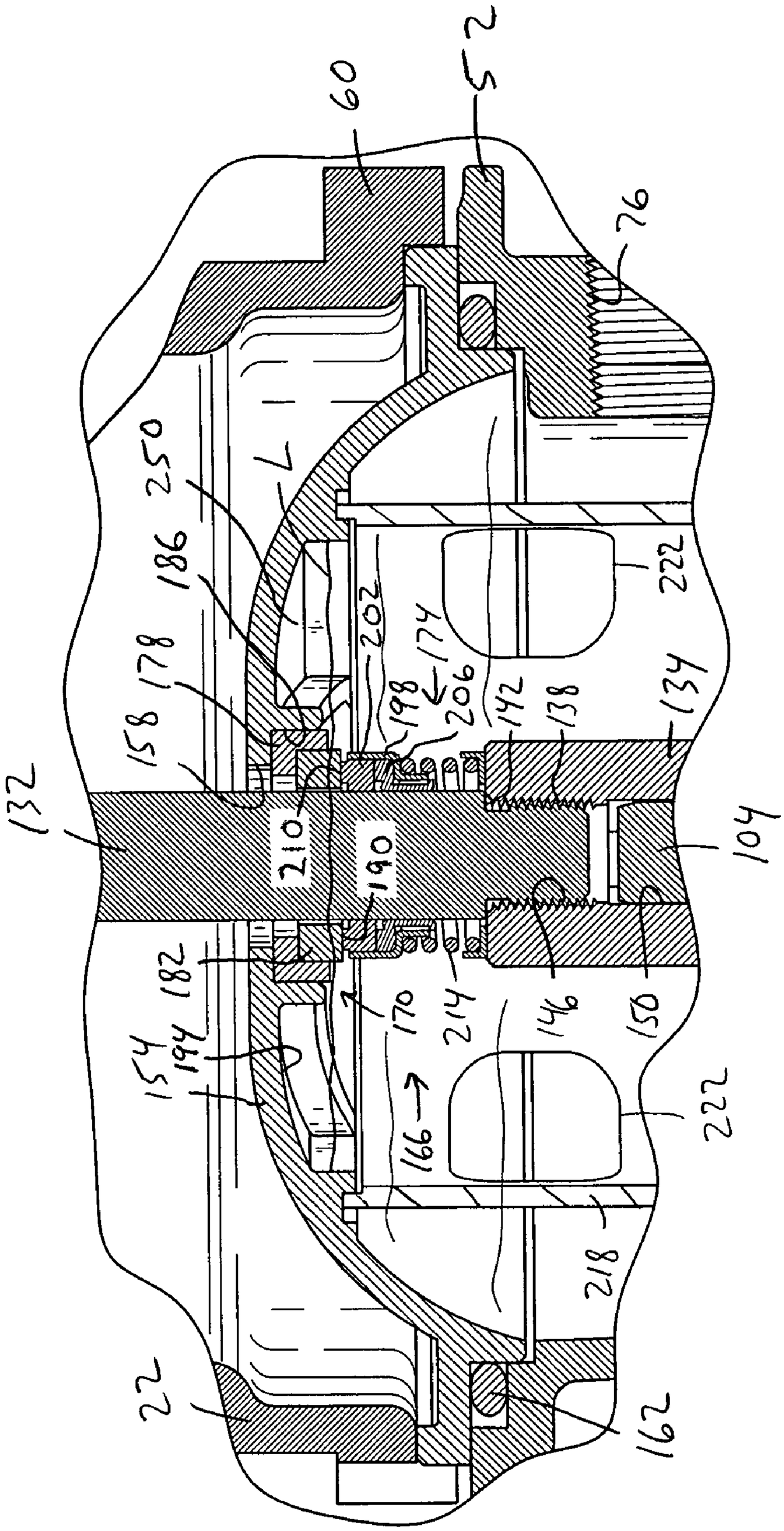
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FIG. 6b

PUMP

FIELD OF THE INVENTION

This invention relates generally to pumps, and more particularly to readily serviceable pumps.

BACKGROUND OF THE INVENTION

Pumps are typically utilized in various applications to increase the pressure of fluid provided by a fluid source. Conventional pumps can include an inlet to connect to an inlet conduit providing fluid from the fluid source at an initial pressure, and an outlet to connect to an outlet conduit carrying pressurized fluid away from the pump. Servicing conventional pumps typically requires disconnecting the inlet and outlet conduits from the pumps and completely disassembling the pumps to gain access to the pumps' internal components. As a result, the inlet and outlet conduits must be reconnected to the pumps after the pumps are serviced. Such a process often results in extended periods of downtime. Also, having to frequently disconnect and reconnect the inlet and outlet conduits and the pumps can increase the likelihood of leakage between the conduits and the pumps.

SUMMARY OF THE INVENTION

Some embodiments of the present invention provide a pump including a pump housing having an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit. The pump also includes a pump shaft rotatably supported in the pump housing and a plurality of impellers coupled for rotation with the pump shaft. The plurality of impellers are operable to pressurize a fluid in the pump housing. The pump further includes a motor removably coupled to the pump housing. The motor has an output shaft drivably coupled to the pump shaft. The pump also includes a spacer positioned between the plurality of impellers and the motor. The spacer is coaxial with the output shaft and the pump shaft. The spacer includes at least one aperture located and sized to enable access the output shaft and the pump shaft to de-couple the output shaft and the pump shaft. The motor, spacer, pump shaft, and the plurality of impellers are removable from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing.

Other embodiments of the present invention provide a pump including a pump housing having an inlet adapted to fluidly couple with an inlet conduit and an outlet adapted to fluidly couple with an outlet conduit, a pump shaft rotatably supported in the pump housing, and a plurality of impellers coupled for rotation with the pump shaft. The plurality of impellers are operable to pressurize a fluid in the pump housing. The pump also includes a motor coupled to the pump housing. The motor has an output shaft drivably coupled to the pump shaft. The pump further includes a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing. The seal cap includes an aperture dimensioned to receive one of the output shaft and the pump shaft. The pump also includes a seal assembly having a stationary seal coupled to the seal cap and coaxial with the aperture. The stationary seal has a stationary surface. The seal assembly also has a rotating seal coupled for rotation with the one of the output shaft and the pump shaft. The rotating seal has a rotating surface engageable with the stationary surface. The stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap.

Some embodiments of the present invention provide a method of servicing a pump. The method includes providing a pump housing fixed to a support surface. The pump housing includes an inlet fluidly coupled with an inlet conduit and an outlet fluidly coupled with an outlet conduit. The method also includes providing a pump assembly in the pump housing and a motor drivably coupled to a portion of the pump assembly. The motor is coupled to the pump housing and spaced from a remaining portion of the pump assembly by a spacer. The method further includes de-coupling the motor from the pump housing and removing the motor and the pump assembly from the pump housing as a single unit while the inlet conduit remains fluidly coupled with the pump housing inlet, and the outlet conduit remains fluidly coupled with the pump housing outlet. The method also includes accessing an interface between the motor and the pump assembly through an aperture in the spacer to de-couple the motor and the pump assembly and separating the motor from the pump assembly.

Other embodiments of the present invention provide a pump including a pump housing having an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit, and a pump assembly operable to pressurize a fluid in the pump housing. The pump assembly includes a pump shaft rotatably supported in the pump housing, at least one impeller coupled for rotation with the pump shaft, at least one suction cap positioned upstream of the at least one impeller, at least one diffuser positioned downstream of the at least one impeller, and a retainer coupled to the pump shaft downstream of the at least one diffuser. The pump also includes a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft. The motor is removable from the pump housing with the pump assembly as a single unit.

Yet other embodiments of the present invention provide a method of servicing a pump. The method includes providing a pump housing coupled to a support surface. The pump housing includes an inlet fluidly coupled with an inlet conduit, and an outlet fluidly coupled with an outlet conduit. The method also includes providing a pump assembly in the pump housing. The pump assembly includes a pump shaft rotatably supported in the pump housing, at least one impeller coupled for rotation with the pump shaft, at least one suction cap positioned upstream of the at least one impeller, at least one diffuser positioned downstream of the at least one impeller, and a retainer coupled to the pump shaft downstream of the at least one diffuser. The method further includes providing a motor drivably coupled to the pump shaft, de-coupling the motor from the pump housing, and removing the motor and the pump assembly from the pump housing as a single unit.

Other features and aspects of the present invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference numerals indicate like parts:

FIG. **1** is an exploded perspective view of a pump of the present invention.

FIG. **2** is an assembled, partial cross-sectional view of the pump of FIG. **1**, illustrating an inlet conduit and an outlet conduit fluidly coupled to the pump.

FIG. **3** is a partially-exploded perspective view of the pump of FIG. **1**, illustrating a motor and a pump assembly being removed from a pump housing while maintaining the connections of the inlet conduit and the outlet conduit to the pump housing.

FIG. **4***a* is an enlarged, partially-exploded perspective view of the pump of FIG. **1**, illustrating an output shaft of the motor being disconnected from a coupling joining the output shaft to a pump shaft.

FIG. **4***b* is an enlarged, partially-exploded perspective view of the pump of FIG. **1**, illustrating the coupling disconnected from the output shaft.

FIG. **5** is an exploded perspective view of an alternative embodiment of the output shaft and the coupling of the pump of FIG. **1**.

FIG. **6***a* is an enlarged, partial cross-sectional view through the pump of FIG. **1**, illustrating a seal plate and a mechanical seal.

FIG. **6***b* is an enlarged view of the seal plate and mechanical seal of FIG. **6***a*.

Before any features of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including", "having", and "comprising" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The use of letters to identify elements of a method or process is simply for identification and is not meant to indicate that the elements should be performed in a particular order.

DETAILED DESCRIPTION

FIGS. **1-6***b* illustrate a pump **10** constructed in accordance with some embodiments of the present invention. With reference to FIGS. **1-3**, the pump **10** generally includes a pump housing **14**, a pump assembly **18** positioned in the pump housing **14**, and a motor **22** coupled to the pump housing **14** and drivably coupled to the pump assembly **18** along a central axis **26**. As shown in FIG. **3**, the pump housing **14** generally includes an inlet portion **30** and an outlet or discharge portion **34**. The inlet portion **30** and the discharge portion **34** can be coupled using any of a number of different methods such as, for example, welding or brazing, using a threaded connection, using tie rods, and so forth. If threads or tie rods, for example, are utilized to couple the inlet portion **30** and the discharge portion **34**, an O-ring (not shown) or other seal (e.g., a square ring, quad ring, etc.) can be utilized to seal the inlet portion **30** to the discharge portion **34**. Alternatively, the discharge portion **34** can be integrally formed with the inlet portion **30**, such that the pump housing **14** is a one-piece construction. In the illustrated embodiment, the discharge portion **34** is shown as a two-piece construction that is joined together by a welding process, for example. Alternatively, the discharge portion **34** can be a one-piece construction.

The inlet portion **30** includes a base **36** for mounting the pump housing **14** to a support surface **40** (see FIG. **6***a*). The base **36** includes a plurality of apertures **44** through which fasteners **48** (e.g., bolts, screws, etc.) can be passed to mount the pump housing **14** to the support surface **40**. Alternatively, the base **36** can include other mounting structure configured to mount to mating mounting structure fixed to the support surface **40**.

The inlet portion **30** also includes a flange **52** for mounting the motor **22** to the pump housing **14**. In the illustrated embodiment of FIG. **1**, the flange **52** incorporates a square bolt pattern including four apertures **56**. The motor **22** includes a flange **60** incorporating a plurality of apertures **64** conforming to the same square bolt pattern, such that fasteners **68** (e.g., bolts) can be passed through the respective apertures **64**, **56** in the motor flange **60** and the pump housing flange **52** to secure the motor **22** to the pump housing **14**. As a result, the motor **22** can be mounted with respect to the pump housing **14** in four different orientations, thereby allowing external electrical connections (not shown) to the motor **22** to be conveniently oriented with respect to the support surface **40**.

Alternatively, the flange **60** of the motor **22** and the flange **52** of the pump housing **14** can incorporate a bolt pattern having more or less than four apertures, or other connection techniques can be used. Further, the bolt pattern on the pump housing flange **52** can be arranged to include a multiple of the apertures on the motor flange **60**, thereby allowing the motor **22** to be mounted to the pump housing **14** in a multiple of different orientations. In the illustrated embodiment, the apertures **56** in the pump housing flange **52** are threaded to receive the fasteners **68**. However, the apertures **64** in the motor flange **60** can alternatively be threaded to receive the fasteners **68**. A handle **72** can also be coupled to the motor flange **60** as a convenience when transporting or installing the pump **10**.

The inlet portion **30** of the pump housing **14** includes an inlet **76** for fluidly coupling an inlet conduit **80** (see FIG. **2**) to the pump housing **14**. The inlet conduit **80** can be configured as a pipe, a hose, or any other fluid-carrying body that delivers a fluid (e.g., water) to the inlet portion **30** of the pump housing **14** from a fluid source at an initial pressure. As shown in FIG. **2**, the inlet **76** is defined along an axis **84** substantially perpendicular with the central axis **26**. The inlet **76** can be threaded to receive a fluid coupling **88** for connecting the inlet conduit **80**.

FIG. **1** shows the tubular discharge portion **34** enclosing most of the pump assembly **18**. The tubular discharge portion **34** includes an outlet **92** defined along the central axis **26** for fluidly coupling an outlet conduit **96** (see FIG. **2**) to the pump housing **14**. Like the inlet conduit **80**, the outlet conduit **96** can be configured as a pipe, a hose, or any other fluid-carrying body that transports pressurized fluid from the pump **10**. Like the inlet **76**, the outlet **92** can be threaded to receive a fluid coupling **100** for connecting the outlet conduit **96**. The pump assembly **18** pressurizes the fluid as the fluid flows from the inlet **76** to the outlet **92**. The outlet conduit **96** then carries the pressurized fluid from the pump housing **14**. In alternative embodiments of the invention, the pump assembly **18** can be configured to pressurize the fluid as the fluid flows from the outlet **92** to the inlet **76**, effectively reversing the flow through the pump **10**.

With reference to FIG. **1**, the pump assembly **18** includes a pump shaft **104** and a plurality of hydraulic stages **108** arranged end-to-end along the pump shaft **104**. As shown in FIG. **2**, the pump shaft **104** is supported for rotation in the pump housing **14**. As shown in FIGS. **1** and **2**, each hydraulic stage **108** includes an impeller **112** coupled for rotation with the pump shaft **104**. In the illustrated embodiment, the pump shaft **104** includes a hexagonal outer shape or surface and the impellers **112** include respective hubs **114** having hexagonal bores **118** to receive the hexagonal pump shaft **104**. Alternatively, the impellers **112** can be permanently connected to the pump shaft **104** by methods such as, for example, welding or brazing.

Each hydraulic stage **108** also includes a suction cap **122** upstream of the impeller **112** and a diffuser **126** downstream of the impeller **112**. U.S. Pat. No. 5,407,323, incorporated herein by reference in its entirety, includes additional disclosure relating to the suction cap **122**, impeller **112**, and the

diffuser **126**. In the illustrated pump assembly **18**, twelve hydraulic stages **108** are shown. However, alternative embodiments of the invention can incorporate more or fewer than twelve hydraulic stages **108**. Accordingly, alternative embodiments of the invention can include only a single hydraulic stage **108**.

Each hydraulic stage **108** is individually operable to pressurize the fluid in the pump housing **14**. The pressure of the fluid in the pump housing **14** is incrementally increased due to each subsequent stage **108** as the fluid flows from the inlet **76** to the outlet **92**. In each stage **108**, the suction cap **122** guides the fluid toward the impeller **112**, which accelerates the fluid radially outwardly. The accelerated fluid is then slowed by the diffuser **126**, converting a portion of the energy of the accelerated fluid into pressure. The suction cap **122** of an adjacent stage **108** then guides the pressurized fluid into the impeller **112** of the adjacent stage **108** for additional pressurizing.

With reference to FIG. **2**, a retainer in the form of a C-clip **130** is coupled to the discharge end of the pump shaft **104** downstream of the hydraulic stages **108**. The C-clip **130** prevents the hydraulic stages **108** from sliding off the discharge end of the pump shaft **104**. At the inlet end of the pump shaft **104**, a portion of the hexagonal-shaped pump shaft **104** (see FIG. **1**) is drivably coupled to an output shaft **132** of the motor **22** via an interface or a coupling **134**. In some embodiments, the output shaft **132** includes a threaded portion **138** and a shoulder **142** adjacent the threaded portion **138**. As shown in FIG. **2**, the coupling **134** includes an internally-threaded portion **146** configured to engage the threaded portion **138** of the output shaft **132**, and an internal hexagonal-shaped portion **150** configured to receive the hexagonal-shaped pump shaft **104**. In the illustrated embodiment, the hexagonal-shaped pump shaft **104** is press-fit into the internal hexagonal-shaped portion **150** of the coupling **134**. Accordingly, the coupling **134** is not easily disconnected from the pump shaft **104**.

With reference to FIG. **1**, a seal cap or a seal plate **154** is positioned between the motor **22** and the pump housing **14** to at least partially seal the pump housing **14**. The seal plate **154** includes an aperture **158** to receive the output shaft **132** of the motor **22**. In alternative embodiments of the invention, the pump shaft **104** can extend through the aperture **158** in the seal plate **154**, and the coupling **134** can be positioned between the motor **22** and the seal plate **154**. When the motor **22** is coupled to the pump housing **14**, the seal plate **154** is forced against the flange **52** of the pump housing **14**. An O-ring **162** can enhance sealing between the seal plate **154** and the flange **52** of the pump housing **14** to substantially prevent leakage between the seal plate **154** and the flange **52** of the pump housing **14**. Alternatively, the O-ring **162** can be in the form of a differently configured seal (e.g., a square ring, quad ring, etc.).

As shown in FIGS. **1**, **6***a*, and **6***b*, a seal assembly in the form of a mechanical seal **166** is utilized to substantially prevent leakage between the output shaft **132** and the aperture **158** in the seal plate **154**. The mechanical seal **166** generally includes a stationary seal **170** fixed to the seal plate **154** and a rotating seal **174** fixed for rotation with the output shaft **132**. The stationary seal **170** includes an elastic cup or ring **178** and a ceramic ring **182** extending from the elastic ring **178**. In the illustrated embodiment, the elastic ring **178** can be made from rubber or any other elastomer. The elastic ring **178** is sized and configured to be received into a recess **186** formed in the seal plate **154**. The elastic ring **178** can be pressed into the recess **186** to provide a seal between the outer periphery of the elastic ring **178** and the inner periphery of the recess **186** as is known in the art. As shown in FIGS. **6***a* and **6***b*, the ceramic ring **182** includes a stationary surface **190** axially spaced from an interior surface **194** of the seal plate **154**.

The rotating seal **174** includes a housing **198** having coupled thereto a carbon ring **202** and an elastic shaft seal **206**. The carbon ring **202** is concentric with the ceramic ring **182**, and includes a rotating surface **210** facing the stationary surface **190** of the stationary seal **170**. The elastic shaft seal **206** fits snugly against the output shaft **132** to provide a seal as is known in the art. The rotating seal **174** also includes a compression spring **214** biasing the rotating surface **210** against the stationary surface **190** to provide a seal between the rotating surface **210** and the stationary surface **190** as is known in the art. In the illustrated embodiment, the spring **214** is at least partially compressed between the housing **198** and the coupling **134** to provide the biasing force. As shown in FIG. **2**, the coupling **134** is threaded onto the output shaft **132** until the coupling **134** abuts the shoulder **142** of the output shaft **132**, which determines the amount that the spring **214** is compressed and establishes the biasing force of the rotating surface **210** against the stationary surface **190**. The mechanical seal **166** and the seal plate **154** substantially prevents fluid from leaking out of the pump housing **14**.

FIGS. **1** and **2** illustrate a spacer **218** positioned between the seal plate **154** and the hydraulic stages **108**. When the pump **10** is assembled, the spacer **218** engages the seal plate **154** at one end and the suction cap **122** of the hydraulic stage **108** disposed closest to the inlet **76**. The spacer **218** is positioned to intersect the axis **84** of the inlet **76**. The spacer **218** includes a plurality of apertures **222** that allow fluid to flow from the inlet **76** through the spacer **218**. In addition to engaging the seal plate **154** when the pump **10** is assembled, the spacer **218** at least partially compresses the suction caps **122** and the diffusers **126** of the respective hydraulic stages **108** against each other, and at least partially compresses the diffuser **126** closest to the outlet **92** against a shoulder **224** inside the tubular discharge portion **34** of the pump housing **14**. This prevents significant leakage of fluid between adjacent hydraulic stages **108**.

With reference to FIGS. **3**-**4***b*, the serviceability of the pump **10** is improved over conventional pumps. More particularly, the installation and removal of the motor **22** and pump assembly **18** with respect to the pump housing **14** is simplified compared to conventional pumps. To remove the pump assembly **18** from the pump housing **14**, as shown in FIG. **3**, the fasteners **68** are removed from the pump housing **14**, and the motor **22** and pump assembly **18** can be pulled out from the pump housing **14** along the central axis **26** as a single unit. The C-clip **130** (or other retention device) on the pump shaft **104** enables the entire stack of hydraulic stages **108** to be pulled out of the pump housing **14** with the pump shaft **104** and the motor **22**. As a result, the inlet conduit **80** can remain connected to the inlet **76** of the pump housing **14**, and the outlet conduit **96** can remain connected to the outlet **92** of the pump housing **14** during pump servicing.

The coupling **134** can be disengaged from the output shaft **132** to separate the motor **22** from the pump assembly **18**. With reference to FIG. **4***a*, an end cap **226** of the motor **22** can be removed to expose the end of the output shaft **132**. The end of the output shaft **132** includes a slot **230** that can be engaged by a tool (e.g., a screwdriver **234**) to rotationally secure the output shaft **132**. Alternatively, other methods of securing the output shaft **132** relative to the housing of the motor **22** can be utilized.

Further, another tool (e.g., an open-end wrench **238**) can be inserted through one of the apertures **222** of the spacer **218** to engage the hexagonal-shaped pump shaft **104**. The wrench **238** can then incrementally rotate the pump shaft **104**, thereby

causing the threaded portion **146** of the coupling **134** to disengage the threaded portion **138** of the output shaft **132**. Alternatively, the wrench **238** can be used to rotationally secure the pump shaft **104**, and the screwdriver **234** can be rotated to rotate the output shaft **132** relative to the coupling **134** to disengage the threaded portion **146** of the coupling **134** from the threaded portion **138** of the output shaft **132**. Upon disengaging the coupling **134** and the output shaft **132** (see FIG. **4***b*), the motor **22** can be moved away from the spacer **218** to expose the seal plate **154**. Further, rotating seal **174** of the mechanical seal **166** can be removed from the output shaft **132**, the seal plate **154** can be disengaged from the motor **22**, and the stationary seal **170** of the mechanical seal **166** can be disengaged and removed from the seal plate **154**. At this time, the mechanical seal **166**, the seal plate **154**, and/or the O-ring **162** can be inspected, repaired, and/or replaced.

The coupling **134** can be removed from the pump shaft **104** to remove the hydraulic stages **108** from the pump shaft **104**. To remove the coupling **134**, the coupling **134** can be pulled from the pump shaft **104**, however, sufficient force is required to overcome the resistance of the press fit between the internal hexagonal-shaped portion **150** of the coupling **134** and the hexagonal-shaped pump shaft **104**. Any of a number of different tools can be utilized to assist a user with pulling the coupling **134** from the pump shaft **104**. Alternatively, the hydraulic stages **108** can be removed from the discharge end of the pump shaft **104** opposite the coupling **134**. To accomplish this, the C-clip **130** must be removed from the pump shaft **104**.

Once the coupling **134** is disengaged from the pump shaft **104**, one or more of the hydraulic stages **108** can be removed from the pump shaft **104** for inspection, repair, or replacement. The installation of the motor **22** and pump assembly **18** into the pump housing **14** is the reverse of the process outlined above.

With reference to FIG. **5**, the output shaft **132** and the coupling **134** can utilize a slip-fit connection rather than the threaded connection. For example, the output shaft **132** can include an external flat **242**, and the coupling **134** can include an internal flat **246** configured to engage the external flat **242** of the output shaft **132**. Alternatively, the output shaft **132** can include a plurality of splines, and the coupling **134** can include a plurality of internal splines configured to engage the splines on the output shaft **132**. Such slip-fit connections can allow the motor **22** to be removed from the pump housing **14** separately from the pump assembly **18**. As a result, if only the motor **22** required servicing and/or replacement, the pump assembly **18** can be left in the pump housing **14**.

With reference to FIGS. **6***a* and **6***b*, the pump **10** is shown mounted in a substantially vertical orientation with fluid in the pump housing **14**. The level of the fluid is represented by line L. As shown in FIGS. **6***a* and **6***b*, the interface between the stationary surface **190** and the rotating surface **210** is substantially submerged in the fluid beneath line L. By maintaining both of the stationary and rotating surfaces **190**, **210** submerged in the fluid, heat due to friction between the surfaces **190**, **210** can be dissipated into the fluid. If the surfaces **190**, **210** do not remain substantially submerged in the fluid, the heat due to friction can build up and possibly damage the mechanical seal **166**.

During start-up of the pump **10**, air trapped in the system typically accumulates toward the top of the seal plate **154**. As the trapped air is eventually worked out of the system, the fluid level is allowed to rise above line L. The illustrated seal plate **154** provides sufficient spacing between the stationary surface **190** and the interior top surface **194** of the seal plate **154** to allow accumulation of the trapped air while maintaining the stationary and rotating surfaces **190**, **210** substantially submerged in the fluid. Such spacing between the fluid at line L and the interior top surface **194** of the seal plate **154** can define a substantially annular air entrapment chamber **250**. Conventional pumps do not provide such an air entrapment chamber, thereby causing the seals of the conventional pumps to often run dry during the start-up period of the conventional pumps.

Various aspects of the present invention are set forth in the following claims.

I claim:

1. A pump comprising:

a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;

a pump shaft rotatably supported in the pump housing;

a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;

a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft; and

a spacer positioned between the plurality of impellers and the motor and coaxial with the output shaft and the pump shaft, the spacer including at least one aperture located and sized to enable access to the output shaft and the pump shaft to de-couple the output shaft and the pump shaft, allowing the motor, the spacer, the pump shaft, and the plurality of impellers to be removed from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing; and

a suction cap positioned upstream of each impeller; and

a diffuser positioned downstream of each impeller;

wherein the spacer at least partially compresses the suction caps and the diffusers against a portion of the pump housing when the motor is coupled to the pump housing.

2. The pump of claim **1**, wherein the pump housing includes a base portion adapted to mount to a support surface.

3. The pump of claim **1**, wherein the pump shaft is coaxial with a central axis through the pump housing, wherein the inlet is defined along an axis substantially perpendicular to the central axis, and wherein the outlet is coaxial with the central axis.

4. The pump of claim **1**, wherein the pump shaft includes a hexagonal outer surface, and wherein the plurality of impellers include respective hubs having hexagonal bores to receive the pump shaft.

5. The pump of claim **1**, wherein a combination of a single suction cap, a single impeller, and a single diffuser comprises a single hydraulic stage.

6. The pump of claim **5**, wherein a plurality of hydraulic stages are stacked end-to-end in the pump housing.

7. The pump of claim **1**, further comprising a retainer coupled to an end of the pump shaft opposite the motor, the retainer allowing the plurality of diffusers and suction caps to be removed from the pump housing with the pump shaft and the plurality of impellers.

8. The pump of claim **1**, wherein the motor is mountable to the pump housing in at least two different orientations.

9. The pump of claim **1**, further comprising a coupling joining the output shaft and the pump shaft.

10. The pump of claim **9**, wherein a tool is insertable through the aperture in the spacer to disengage the coupling from at least one of the output shaft and the pump shaft.

11. The pump of claim **9**, wherein a slip-fit connection is utilized between the coupling and the output shaft.

12. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;
a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;
a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft; and
a spacer positioned between the plurality of impellers and the motor and coaxial with the output shaft and the pump shaft, the spacer including at least one aperture located and sized to enable access to the output shaft and the pump shaft to de-couple the output shaft and the pump shaft, allowing the motor, the spacer, the pump shaft, and the plurality of impellers to be removed from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing; and
a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture to receive therethrough one of the output shaft and the pump shaft;
a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface; and
a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seal having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap.

13. The pump of claim 12, wherein the seal comprises a mechanical seal including a stationary seal and a rotating seal engageable with the stationary seal, and wherein the stationary seal and the rotating seal are axially spaced from the interior surface of the seal cap.

14. The pump of claim 13, wherein the stationary seal and the rotating seal are at least partially submerged in the fluid in the pump housing during operation of the pump, and wherein an air entrapment chamber is defined between the interior surface of the seal cap and the fluid when the pump is substantially vertically oriented.

15. The pump of claim 12, wherein the seal cap is positioned between the motor and the spacer.

16. The pump of claim 12, further comprising a seal positioned between the seal cap and the pump housing to substantially prevent leakage between the seal cap and the pump housing.

17. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;
a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;
a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft; and
a spacer positioned between the plurality of impellers and the motor and coaxial with the output shaft and the pump shaft, the spacer including at least one aperture located and sized to enable access to the output shaft and the pump shaft to dc-couple the output shaft and the pump shaft, allowing the motor, the spacer, the pump shaft, and the plurality of impellers to be removed from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing;
wherein the motor includes a flange having a bolt pattern, and wherein the pump housing includes a flange having at least one corresponding bolt pattern defined thereon.

18. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;
a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;
a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft; and
a spacer positioned between the plurality of impellers and the motor and coaxial with the output shaft and the pump shaft, the spacer including at least one aperture located and sized to enable access to the output shaft and the pump shaft to de-couple the output shaft and the pump shaft, allowing the motor, the spacer, the pump shaft, and the plurality of impellers to be removed from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing;
wherein the motor includes a flange having a first square bolt pattern, and wherein the pump housing includes a flange having a second square bolt pattern substantially identical to the first square bolt pattern.

19. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;
a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;
a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft; and
a spacer positioned between the plurality of impellers and the motor and coaxial with the output shaft and the pump shaft, the spacer including at least one aperture located and sized to enable access to the output shaft and the pump shaft to de-couple the output shaft and the pump shaft, allowing the motor, the spacer, the pump shaft, and the plurality of impellers to be removed from the pump housing as a single unit without disconnecting the inlet conduit and the outlet conduit from the pump housing; and
a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing;
a plurality of suction caps corresponding with the plurality of impellers, each suction cap being positioned upstream of the respective impeller, wherein one end of the spacer engages the seal cap, and wherein an opposite end of the spacer engages one of the plurality of suction caps.

20. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;

a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;

a motor coupled to the pump housing, the motor having an output shaft drivably coupled to the pump shaft;

a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture dimensioned to receive one of the output shaft and the pump shaft; and

a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface; and

a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seat having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap; and

a spacer positioned between the seal cap and the plurality of impellers and coaxial with the output shaft and the pump shaft, the spacer including at least one aperture therethrough to access the motor shaft and the pump shaft to de-couple the motor shaft and the pump shaft.

21. The pump of claim **20**, wherein the pump housing includes a base portion adapted to mount to a support surface.

22. The pump of claim **20**, wherein the pump shaft is coaxial with a central axis through the pump housing, wherein the inlet is defined along an axis substantially perpendicular to the central axis, and wherein the outlet is coaxial with the central axis.

23. The pump of claim **20**, wherein the pump shaft includes a hexagonal outer surface, and wherein the plurality of impellers include respective hubs having hexagonal bores to receive the pump shaft.

24. The pump of claim **23**, further comprising a coupling joining the output shaft and the pump shaft.

25. The pump of claim **20**, further comprising a seal positioned between the seal cap and the pump housing to substantially prevent leakage between the seal cap and the pump housing.

26. The pump of claim **20**, further comprising: a suction cap positioned upstream of each impeller; and a diffuser positioned downstream of each impeller.

27. The pump of claim **26**, wherein a combination of a single suction cap, a single impeller, and a single diffuser comprises a single hydraulic stage.

28. The pump of claim **27**, wherein a plurality of hydraulic stages are stacked end-to-end in the pump housing.

29. The pump of claim **26**, further comprising a retainer coupled to an end of the pump shaft opposite the motor, the retainer allowing the plurality of diffusers and suction caps to be removed from the pump housing with the pump shaft and the plurality of impellers.

30. The pump of claim **20**, wherein the motor includes a flange having a bolt pattern, and wherein the pump housing includes a flange having at least one of the bolt patterns defined thereon.

31. The pump of claim **20**, wherein the motor includes a flange having a first square bolt pattern, and wherein the pump housing includes a flange having a second square bolt pattern substantially identical to the first square bolt pattern.

32. The pump of claim **20**, wherein the motor is mountable to the pump housing in at least two different orientations.

33. The pump of claim **20**, wherein a slip-fit connection is utilized between the output shaft and the pump shaft.

34. The pump of claim **20**, wherein the seal assembly comprises a mechanical seal, and wherein the rotating surface is biased into engagement with the stationary surface by a compression spring.

35. A pump comprising:

a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;

a pump shaft rotatably supported in the pump housing;

a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;

a motor coupled to the pump housing, the motor having an output shaft drivably coupled to the pump shaft;

a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture dimensioned to receive one of the output shaft and the pump shaft;

a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface;

a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seal having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap, wherein the pump shaft includes a hexagonal outer surface, and wherein the plurality of impellers include respective hubs having hexagonal bores to receive the pump shaft; and

a coupling joining the output shaft and the pump shaft;

wherein a tool is insertable through an aperture in a spacer to disengage the coupling from at least one of the output shaft and the pump shaft.

36. A pump comprising:

a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;

a pump shaft rotatably supported in the pump housing;

a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;

a motor coupled to the pump housing, the motor having an output shaft drivably coupled to the pump shaft;

a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture dimensioned to receive one of the output shaft and the pump shaft; and

a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface;

a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seal having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap;

a suction cap positioned upstream of each impeller;

a diffuser positioned downstream of each impeller; and

a spacer positioned between the seal cap and one of the suction caps, wherein the spacer at least partially compresses the suction caps and the diffusers against a portion of the pump housing when the motor is coupled to the pump housing.

37. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;
a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;
a motor coupled to the pump housing, the motor having an output shaft drivably coupled to the pump shaft;
a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture dimensioned to receive one of the output shaft and the pump shaft; and
a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface; and
a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seal having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap;
wherein the motor is coupled to the pump housing by at least one fastener such that the motor, the pump shaft, and the plurality of impellers are removable from the pump housing upon removing the fastener without disconnecting the inlet conduit and the outlet conduit from the pump housing.

38. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump shaft rotatably supported in the pump housing;
a plurality of impellers coupled for rotation with the pump shaft, the plurality of impellers being operable to pressurize a fluid in the pump housing;
a motor coupled to the pump housing, the motor having an output shaft drivably coupled to the pump shaft;
a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture dimensioned to receive one of the output shaft and the pump shaft; and
a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface; and
a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seal having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap;
wherein the stationary surface and the rotating surface are at least partially submerged in the fluid in the pump housing during operation of the pump, and wherein an air entrapment chamber is defined between the interior surface of the seal cap and the fluid when the pump is substantially vertically oriented.

39. A pump comprising:
a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;
a pump assembly operable to pressurize a fluid in the pump housing, the pump assembly including a pump shaft rotatably supported in the pump housing; at least one impeller coupled for rotation with the pump shaft;
at least one suction cap positioned upstream of the at least one impeller; at least one diffuser positioned downstream of the at least one impeller;
a retainer coupled to the pump shaft downstream of the at least one diffuser;
a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft, the motor being removable from the pump housing with the pump assembly as a single unit; and
a spacer positioned between the at least one suction cap and the motor and that is coaxial with the output shaft and the pump shaft, the spacer including at least one aperture therethrough to access the output shaft and the pump shaft to de-couple the output shaft and the pump shaft;
wherein the spacer at least partially compresses the at least one suction cap and the at least one diffuser against a portion of the pump housing when the motor is coupled to the pump housing.

40. The pump of claim 39, wherein the pump housing includes a base portion adapted to mount to a support surface.

41. The pump of claim 39, wherein the pump shaft is coaxial with a central axis through the pump housing, wherein the inlet is defined along an axis substantially perpendicular to the central axis, and wherein the outlet is coaxial with the central axis.

42. The pump of claim 39, wherein the pump shaft includes a hexagonal outer surface, and wherein the at least one impeller includes a hub having a hexagonal bore to receive the pump shaft,

43. The pump of claim 39, wherein a combination of a single suction cap, a single impeller, and a single diffuser comprises a single hydraulic stage.

44. The pump of claim 43, wherein a plurality of hydraulic stages are stacked end-to-end in the pump housing.

45. The pump of claim 39, further comprising: a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing, the seal cap including an aperture to receive therethrough one of the output shaft and the pump shaft; and a seal assembly including a stationary seal coupled to the seal cap and coaxial with the aperture, the stationary seal having a stationary surface; and a rotating seal coupled for rotation with the one of the output shaft and the pump shaft, the rotating seal having a rotating surface engageable with the stationary surface, wherein the stationary surface and the rotating surface are axially spaced from an interior surface of the seal cap.

46. The pump of claim 45, wherein the seal comprises a mechanical seal including a stationary seal and a rotating seal engageable with the stationary seal, and wherein the stationary seal and the rotating seal are axially spaced from the interior surface of the seal cap.

47. The pump of claim 46, wherein the stationary seal and the rotating seal are at least partially submerged in the fluid in the pump housing during operation of the pump, and wherein an air entrapment chamber is defined between the interior surface of the seal cap and the fluid when the pump is substantially vertically oriented.

48. The pump of claim 45, further comprising a seal positioned between the seal cap and the pump housing to substantially prevent leakage between the seal cap and the pump housing.

49. The pump of claim 39, wherein the motor includes a flange having a bolt pattern, and wherein the pump housing includes a flange having at least one corresponding bolt pattern defined thereon.

50. The pump of claim 39, wherein the motor includes a flange having a first square bolt pattern, and wherein the pump

housing includes a flange having a second square bolt pattern substantially identical to the first square bolt pattern.

51. The pump of claim **39**, wherein the motor is mountable to the pump housing in at least two different orientations.

52. The pump of claim **39**, further comprising a coupling joining the output shaft and the pump shaft.

53. The pump of claim **52**, wherein a threaded connection is utilized between the coupling and the output shaft.

54. The pump of claim **52**, wherein a slip-fit connection is utilized between the coupling and the output shaft.

55. A pump comprising:

a pump housing including an inlet adapted to fluidly couple with an inlet conduit, and an outlet adapted to fluidly couple with an outlet conduit;

a pump assembly operable to pressurize a fluid in the pump housing, the pump assembly including a pump shaft rotatably supported in the pump housing; at least one impeller coupled for rotation with the pump shaft;

at least one suction cap positioned upstream of the at least one impeller; at least one diffuser positioned downstream of the at least one impeller;

a retainer coupled to the pump shaft downstream of the at least one diffuser;

a motor removably coupled to the pump housing and having an output shaft drivably coupled to the pump shaft, the motor being removable from the pump housing with the pump assembly as a single unit;

a seal cap positioned between the motor and the pump housing to at least partially seal against the pump housing; and

a spacer positioned between the seal cap and the at least one suction cap, wherein one end of the spacer engages the seal cap, and wherein an opposite end of the spacer engages the at least one suction cap.

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